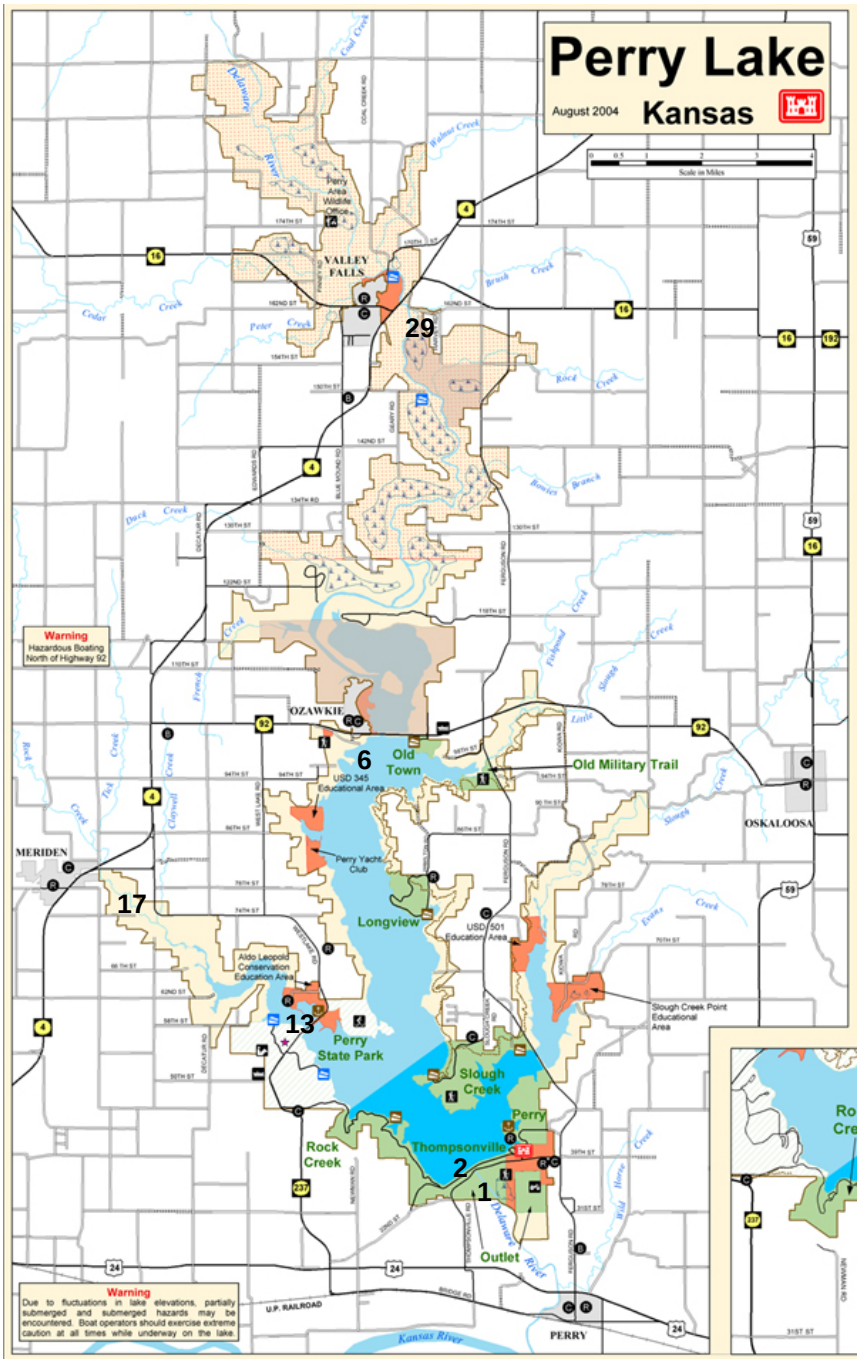
12 Perry Lake

12.1 General Background



Perry Lake was impounded in 1969 and reached full pool in 1970. The main water quality threats to Perry Lake are sedimentation, nutrients and bacterial contamination. The lake is listed on the state's 2004 303(d) list for water quality impairment due to eutrophication and fecal bacteria (inflows). The Delaware River Watershed Restoration and Protection Strategy (WRAPS) is in the process of forming and will develop goals and strategies to improve water quality within the watershed.

12.1.1 Location

Perry Lake, the fourth largest lake in Kansas, is located approximately 20 km (12 miles) northwest of Lawrence, Kansas. The dam is located at river km 8.5 (river mile 5.3)

Figure 12.1. Perry Lake area map with sample site locations and site numbers.

on the Delaware River. The watershed includes portions of Jefferson, Atchison, Brown, Jackson and Nemaha counties. Historic water quality sample sites at Perry Lake include 3 lake, 1 outflow, and 2 inflow (Figure 12.1).

12.1.2 Authorized Purposes: Flood control, water storage, and recreation.

12.1.3 Lake and Watershed Data

Pools	Surface Elevation (ft. above m.s.l.)	Current Capacity (1000 AF)	Surface Area (A)	Shoreline (miles)
Flood Control	920.6	509.3	25,347	
Multipurpose	891.5	206.7	11,146	160
Total		716.0		

Total watershed area: 1,117 sq miles (714,880 A)

Watershed ratio: 28.2 FC / 64.14 MP

Average Annual Inflow: 585,391 acre-feet
Average Annual outflow: 000 acre-feet
Average flushing rate:
Sediment inflow (measured): 49,057 acre-feet (1962 – 2000)

12.2 2005 Activities

Perry Lake was categorized as an 'ambient' lake during 2005, thus only surface samples were collected at three lake sites. Sample collections occurred from May through September 2005, while vertical profiles were recorded at the three lake sites during ??? Perry Lake staff (OF-PE) providing field assistance with the WQP during 2005 included Bunnie Watkins. Ken Wade, OF-PE Operations Manager, provided technical insight and background knowledge on Perry Lake and surrounding watershed.

12.3 2005 Data

Comparative historic data consists of monthly (April – September) data collected from 1996 through 2005.

12.3.1 Inflow

No inflow samples were collected from the Perry Lake watershed during 2005. Historically, nutrient concentrations (nitrogen and phosphorus) are most variable at these sites due to influences of runoff events within the watershed.

12.3.2 Lake

Based on total nitrogen (TN), total phosphorus (TP), and chlorophyll a, Perry Lake is classified as eutrophic. Total nitrogen concentrations from surface samples are relatively consistent between lake sites, outflow, and the Rock Creek (Site 17) inflow, ranging from 0.84 – 1.1 mg/L (Figure 12.2). However, greater concentrations and wider monthly and annual variability in TN was reported at Site 29 (Delaware River

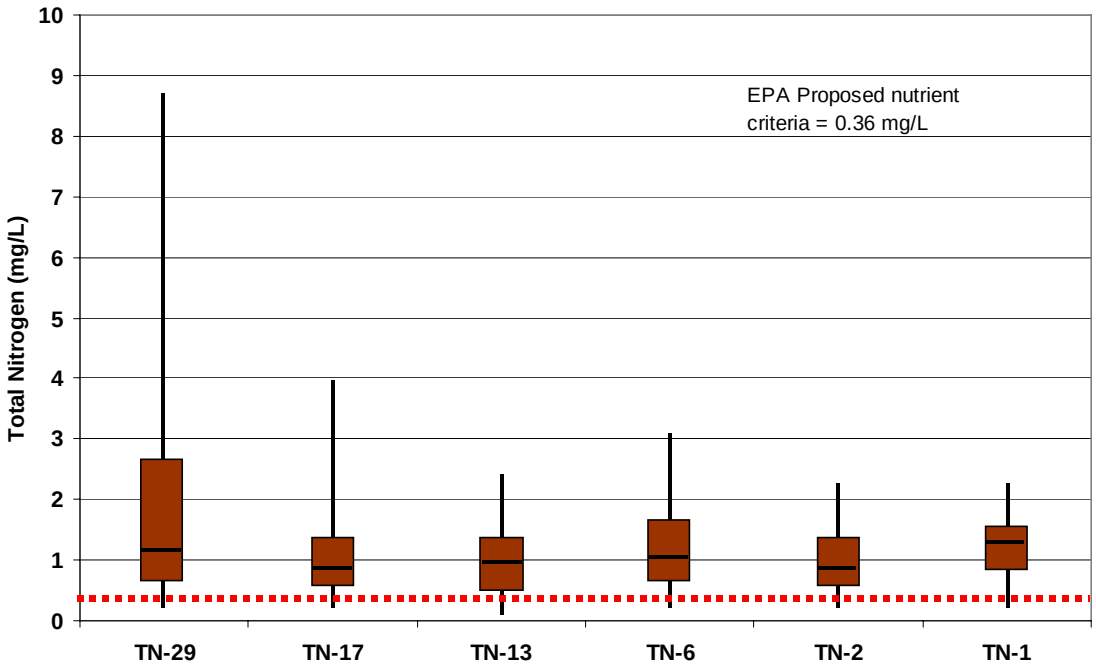


Figure 12.2 Box plots of surface water sample total nitrogen concentrations measured at lake sites from 1996 through 2005 at Perry Lake.

inflow)(Figure 12.3). This would indicate that BMP's targeting TN should be focused along the main tributary of Perry Lake. It should also be noted that all median concentrations are significantly greater than EPA's proposed ecoregional nutrient criteria value of 0.36 mg/L.

Median total phosphorus concentrations from lake sites (0.08 – 0.1 mg/L) were typical of other district lakes (Figure 12.4). Similar to TN, greater concentrations and wider monthly and annual variability in TP concentrations were detected at Site 29 (Delaware River). All median TP concentrations exceed EPA's proposed ecoregional nutrient criteria value of 0.02 mg/L TP. The TP concentrations are typical of other district lakes.

The ratio of TN:TP can be used as a surrogate to determine the dominant algal community within a waterbody. Ratios $\geq$ 20:1 are indicative of desirable algal communities, whereas ratios $\leq$ 12:1 are indicative of bloom-forming cyanobacteria (blue green algae). As would be expected, there is high monthly and annual variability in the TN:TP ratio at all sites; see Figure 12.5 as an example at Site 13 (Rock Creek arm). Median TN:TP ratios at all three lake sites are < 12, indicating the lake is at risk for cyanobacteria blooms (Figure 12.6).

Mean chlorophyll a concentrations ranged from 21 – 28 ug/L for the three lake sites during July – September. Secchi depth measured during September indicated water clarity was very limited in the upper Delaware River arm (Site 6; 0.4 m) and only slightly clearer at the dam (0.63 m). Because the lake was undergoing fall turnover, it is not known how representative these measurements are to ambient water clarity.

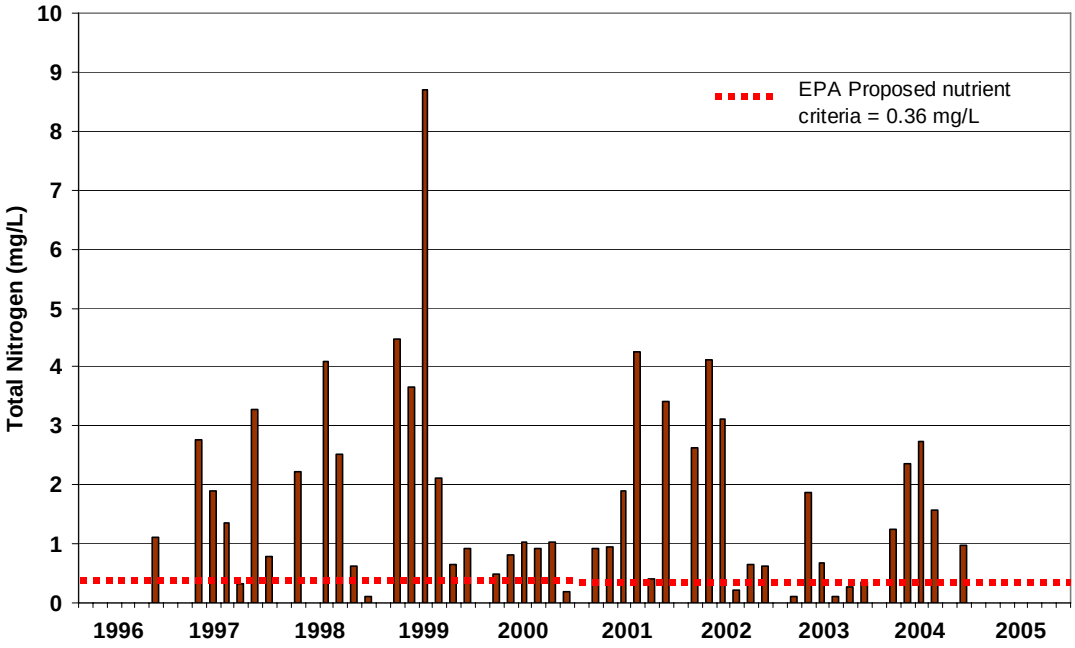


Figure 12.3. Total nitrogen by sample date from surface water samples collected at Site 29 (Delaware River) inflow to Perry Lake from 1996 through 2004.

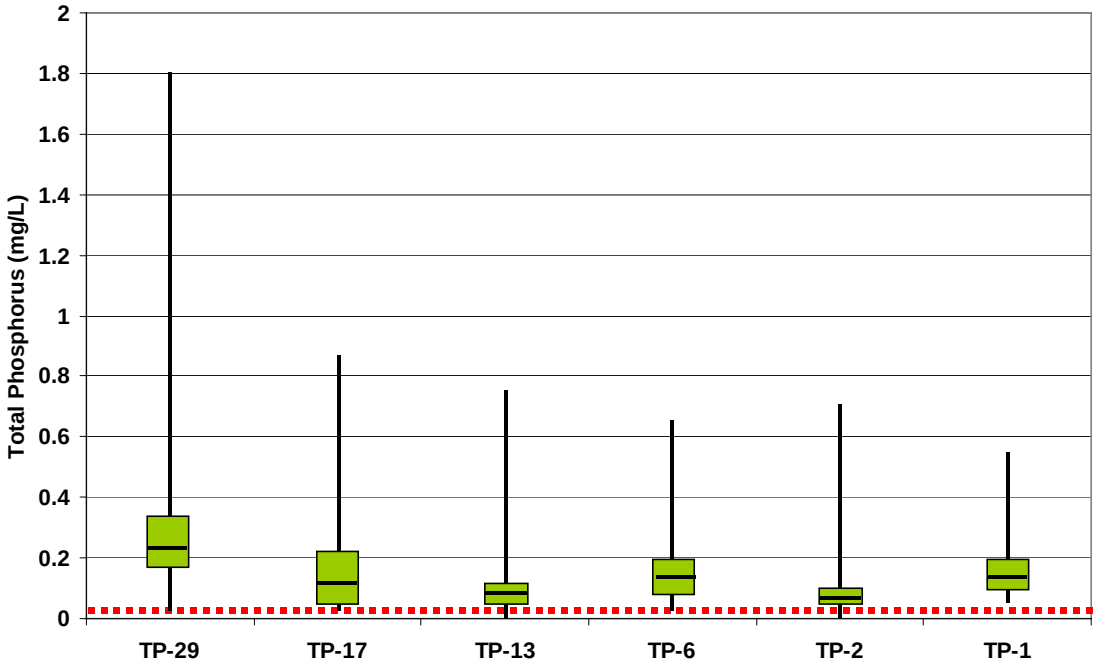


Figure 12.4. Box plots of surface water total phosphorus concentrations measured at lake, inflow (TP-29), and outflow (TP-1) sites from 1996 through 2005 at Perry Lake.

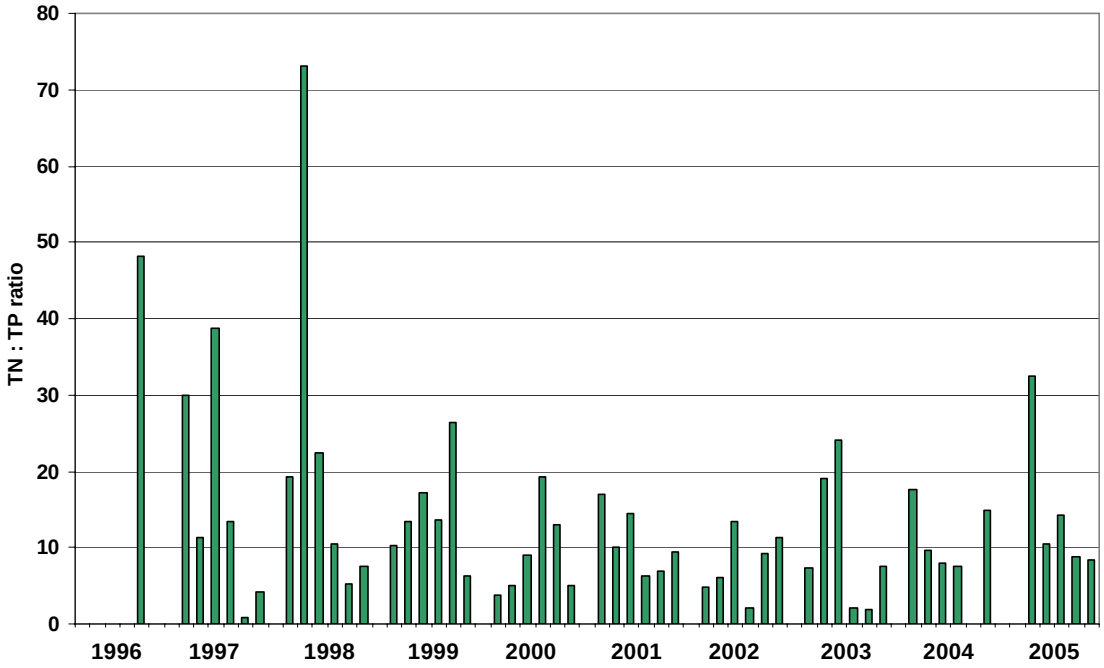


Figure 12.5. Graph of total nitrogen : total phosphorus ratio (TN : TP) by sample date from surface water samples colleted at Site 13 in Perry Lake between 1996 and 2005.

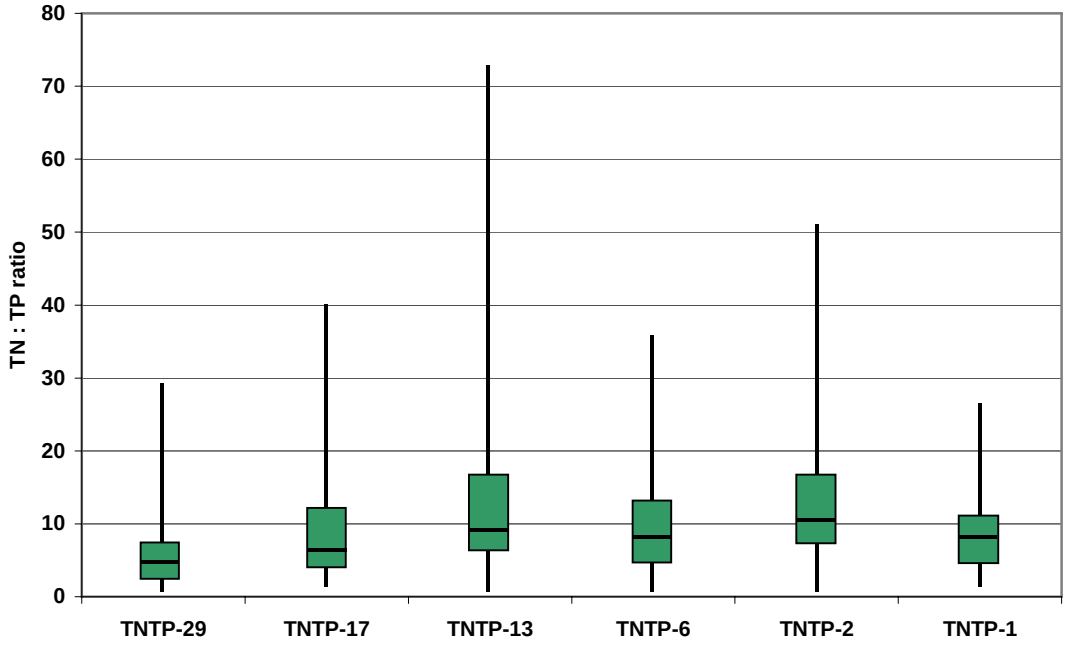


Figure 12.6. Box plots of total nitrogen : total phosphorus ratio (TN : TP) by site from surface water samples collected between 1996 and 2005 at Perry Lake.

Although atrazine samples were not collected during 2005, between 1996 and 2004, median atrazine concentrations (0.56 – 1.56 ug/L) were less than EPA's drinking water maximum contaminant level of 3 ug/L (Figure 12.7). However, individual samples measured during that time period were significant enough to greatly exceed the MCL – even as recent as 2003 a sample was ~ 6X greater than the MCL. Figure 12.8 depicts individual sample concentrations measured by date at Site 29 (Delaware River inflow site).

Perry Lake is the only district lake to exceed the Alachlor MCL of 2 ug/L. As with other contaminants, monthly and annual variability in concentrations is detected; see Figure 12.9 as an example from Site 17 (Rock Creek inflow). Exceedances were detected at both inflow sites as well as Site 6 (Delaware River arm). No exceedances have been detected since 2000, which may be an indication of change in herbicide preference or improved application methods.

Vertical profiles were recorded during July and September sampling trips to Perry Lake. Parameters included temperature, dissolved oxygen, pH, conductivity, and turbidity. Based on these profiles, the lake stratified both chemically and thermally between 4-5 m depth during July (Figure 12.10). Fall turnover was occurring during the September visit based on uniform temperature and dissolved oxygen concentration throughout the water column.

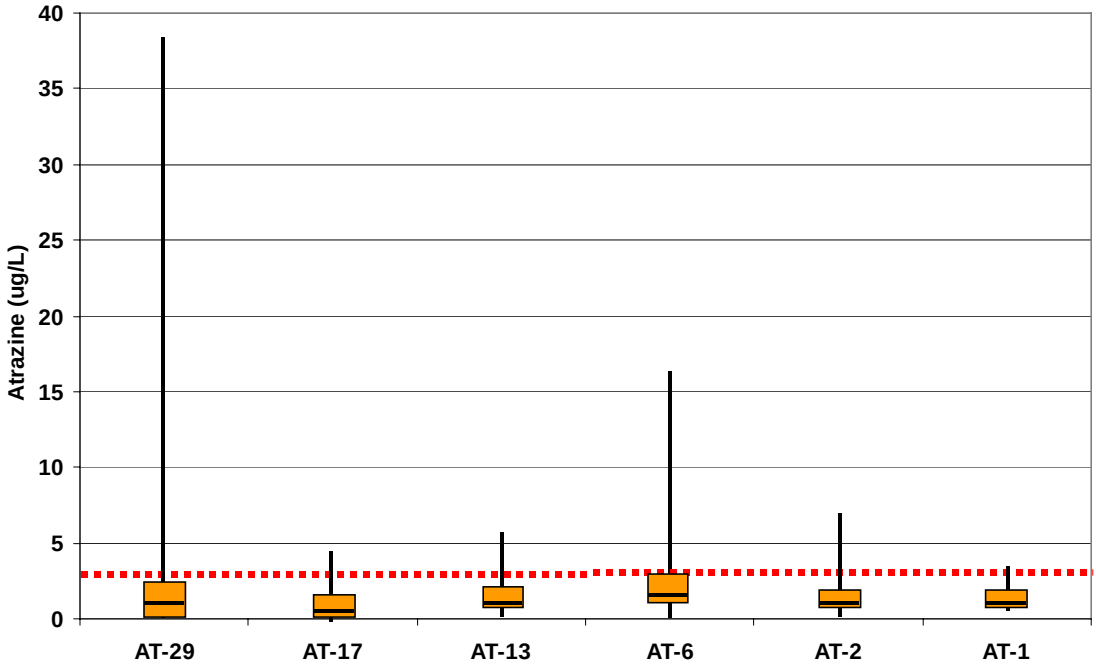


Figure 12.7. Box plots of surface water sample atrazine concentrations measured from 1996 through 2004 at Perry Lake.

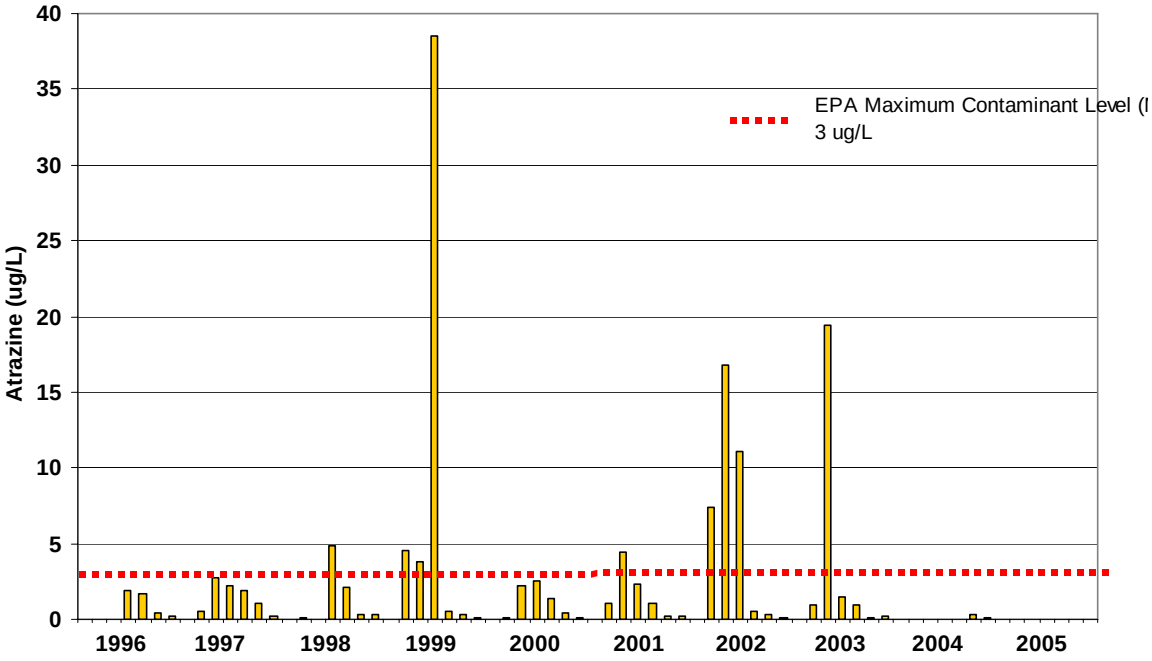


Figure 12.8. Atrazine concentrations by sample date collected from surface water samples at Site 29 (Delaware River) inflow to Perry Lake between 1996 and 2004.

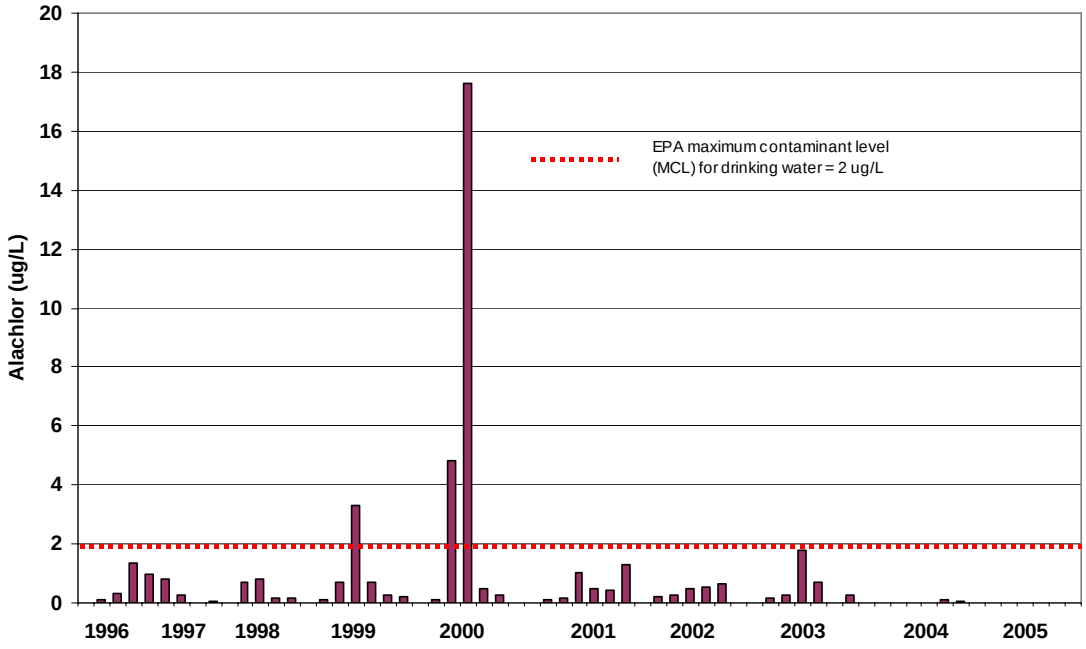


Figure 12.9. Alachlor concentrations by sample date collected from surface water samples at Site 17 (Rock Creek) inflow to Perry Lake between 1996 and 2004.

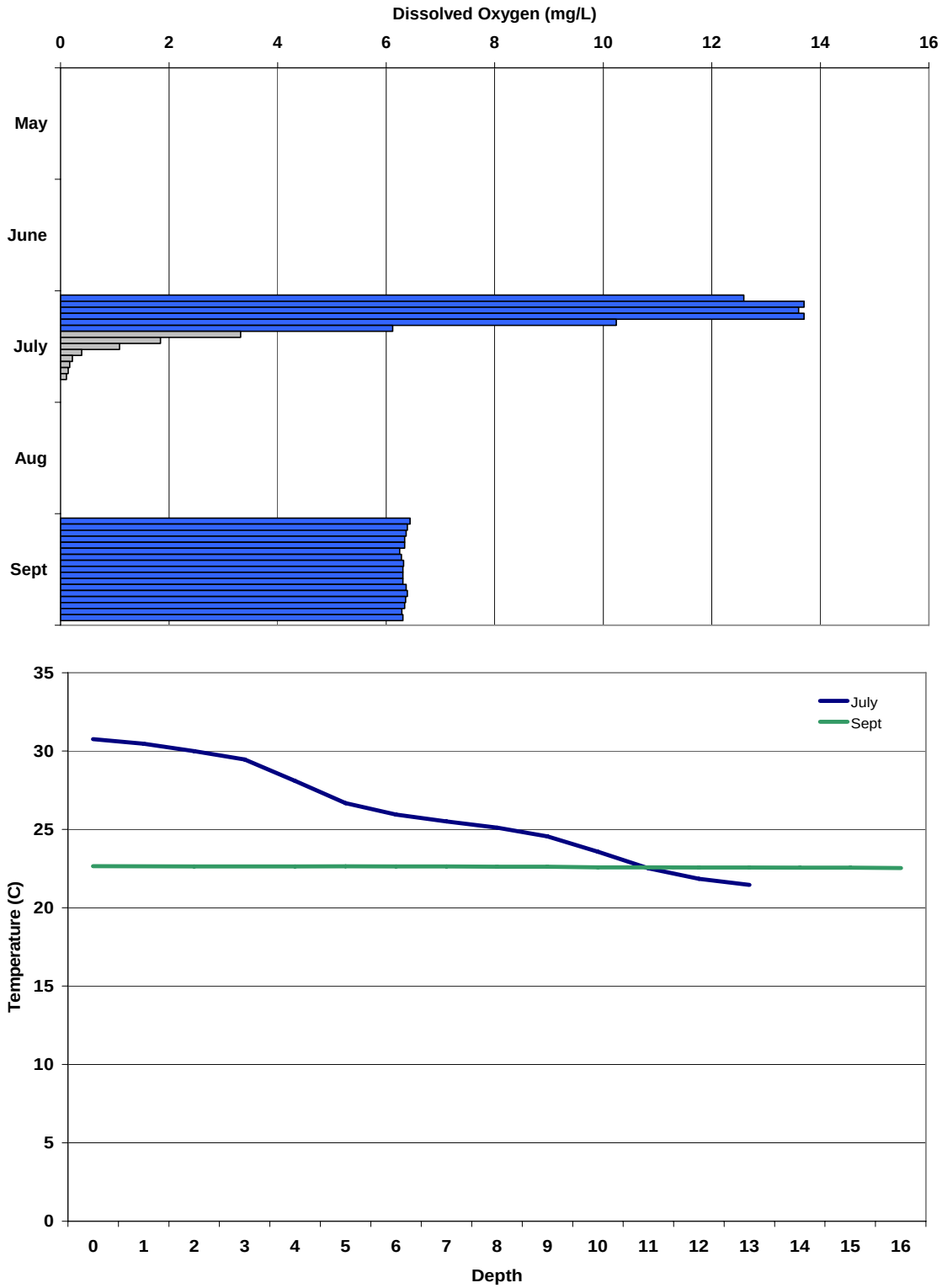


Figure 12.10. Dissolved oxygen concentration (mg/L) histogram and temperature (C plot from vertical profiles recorded at Site 2 (Tower) during 2005 at Perry Lake.

12.3.3 Outflow

No outflow samples were collected from Perry Lake during 2005.

12.4 Future Activities and Recommendations

Sampling activities for 2006 will include continuation of monthly ‘ambient’ monitoring from May through September, as well as conducting at least one summer vertical profile at each of the three lake sites. The Delaware River watershed WRAPS is will be developing goals and targets during mid-2006. Data sharing and active involvement with this group is essential to developing tangible targets for water quality improvement within the Perry Lake watershed.